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BRIEF REPORT

Angry Facial Expressions Hamper Subsequent Target Identification

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Abstract

There is considerable evidence indicating that people are primed to monitor social signals of disapproval. Thus far studies on selective attention have concentrated predominantly on the spatial domain, whereas the temporal consequences of identifying socially threatening information have received only scant attention. Therefore, this study focused on temporal attention costs and examined how the presentation of emotional expressions affects subsequent identification of task-relevant information. High (n =30) and low (n =31) socially anxious women were exposed to a dual target Rapid Serial Visual Presentation (RSVP) paradigm. Emotional faces (neutral, happy, angry) were presented as the first target (T1), and neutral letter stimuli (p, q, d, b) as the second target (T2). Irrespective of social anxiety, the attentional blink was larger for angry compared with happy faces were presented as T1. This apparent prioritized processing of angry faces is consistent with evolutionary models stressing the importance of being especially attentive to potential signals of social threat.

Keywords:

attentional bias; temporal attention; social phobia; facial expressions; attentional blink

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Angry Facial Expressions Hamper Subsequent Target Identification

Emotional facial expressions provide crucial information in the context of social interactions and allow us to infer others' intentions (e.g., Goffman, 1967). Accordingly, several theorists have assigned a special status to the cognitive processing of emotional facial expressions. In this regard it has been argued that threatening faces are associated with the automatic capture of attention (Öhman, 2002) and a prioritized access to limited cognitive resources (e.g., de Jong & Martens, 2007).

A wealth of studies using cognitive tasks and neuropsychological measures showed that briefly presented emotional faces attract attention and are associated with heightened activation of neural structures involved in emotion processing and attention (e.g., Schupp, Öhman, Junghöfer, Weike, Stockburger, & Hamm, 2004). In addition, visual search tasks showed that people are relatively efficient in detecting socially threatening (angry) faces (e.g., Fox, Lester, Russo, Bowles, Pichler, & Dutton, 2000) and become more readily aware of threatening than of positive faces (Eastwood, Smilek, Oakman, Farvolden, vanAmeringen, Mancini, & Merikle, 2005). Consistent with cognitive models of social phobia that assume that socially anxious individuals are hypersensitive for social threat cues (e.g., Rapee & Heimberg, 1997), high socially anxious people have been found to be even more efficient than low socially anxious individuals in this respect (Gilboa-Schechtman, Foa, & Amir, 1999).

Thus far research on selective processing of disapproving faces has concentrated predominantly on the spatial domain, whereas the temporal consequences of identifying socially threatening information have received only scant attention. Yet, prioritized processing of threatening faces may not only facilitate detection of signals of social threat but may also interfere with ongoing task performance (e.g., Bögels & Mansell, 2004). If signs of disapproval are granted prioritized access to limited cognitive resources (e.g., in the context of an ongoing social interaction), detection of disapproval may well hamper the processing of task relevant information that appears within a certain time interval following the detection of the threat signal (cf. Koster, De Raedt, Verschuere, Tibboel, & de Jong, 2009). Such hampered processing of ongoing task relevant information may eventually result in poor social performance (e.g., Baker & Edelmann, 2002).

Research on the temporal characteristics of attentional processes has consistently shown that the ability to identify a particular target (T2) is generally impaired when it is presented in close proximity (100-300 ms) to a preceding first target (T1; Raymond et al., 1992). This deficit in the identification of T2 has been called the *attentional blink* (AB). It is reasoned that this detriment in T2 identification is due to participants' difficulty to efficiently divide attention in a way to process both targets (Olivers & Nieuwenhuis, 2006). Instead, people tend to overinvest attention towards T1, which then occupies limited-capacity visual short term memory (VSTM), leaving no or little room for T2 (Shapiro, Schmitz, Martens, Hommel, & Schnitzler, 2006). It takes some time before attentional resources have recovered (approximately 500 ms), after which T2 processing is no longer impaired.

Studies using affective rather than neutral T2 stimuli showed that the attentional blink effects are smaller for affectively arousing than for neutral verbs (Keil & Ihssen, 2004), indicating that emotional information is preferentially processed. Similarly, a recent RSVP study demonstrated that the attentional blink effect was attenuated for happy and angry compared to neutral faces (de Jong, Koster, van Wees, & Martens, 2009). Similar effects have been reported for fearful faces and aversively conditioned neutral faces (Milders, Sahraie, Logan, & Donnellon, 2006). There is also evidence that the AB for negative emotional faces is sensitive for individual differences in anxiety. It has been shown that the AB for fearful compared to happy faces is further reduced (at lags of 440 ms) in individuals reporting high levels of trait and/or state anxiety (Fox, Russo, & Georgiou, 2005).

Most relevant to the present context, previous research provided evidence to indicate that the appearance of an emotional T1 stimulus may also result in a relatively strong deterioration of the identification of a subsequently appearing T2 stimulus (i.e., enhanced AB). For example, the AB was found to be enhanced when stimuli with highly emotional saliency (i.e, taboo words) were presented as T1 (Mathewson, Arnell, & Mansfield, 2008). Pointing to the relevance of individual differences in this respect, a study comparing high and low dysphoric individuals has shown that specifically in high dysphoric individuals T2 identification was impaired when it was preceded by a negative T1 stimulus word (Koster et al., 2009).

These pieces of evidence show that the preferential processing of emotional stimuli may come at the expense of a subsequent, transient depletion of attentional resources. The major aim of this study was to examine whether the identification of social threat cues would similarly interfere with the identification of subsequently appearing task relevant information. On the basis of our previous research in the context of dysphoria (Koster et al., 2009), we anticipated that this effect would be most pronounced when T2 is presented in close temporal proximity to T1 (300-400 ms). We also investigated the influence of individual differences in social anxiety. Given their social-evaluative concerns, we hypothesized that the prioritized processing of angry faces would be especially pronounced in high socially anxious individuals (cf. Fox et al., 2005) leading to a relatively strong impairing influence of angry T1 faces on the identification of neutral T2 stimuli.

Method

Participants

Participants were 61 undergraduate students who were selected from a larger sample (N = 451) on the basis of their scores on the Social Phobia subscale of the Fear Questionnaire (FQ; Marks & Mathews, 1979). We selected a group of low socially anxious (n = 30; FQ: M = 7.33, SD = 2.73) and a group of high socially anxious women (n = 31, FQ: M = 18.67, SD = 5.08).

From the high anxious participants 38 % fell within the clinical range (FQ > 19; Scholing & Emmelkamp, 1993). In return for participation they received course credits or 5 Euro.

Stimulus materials

As T1 stimuli we used angry, happy, and neutral facial expressions from the Karolinska Directed Emotional Faces (KDEF, Lundqvist, Flykt, & Öhman, 1998) database. We used 25 male and 25 female faces and included from each of these persons all three facial expressions, resulting in 50 happy, 50 angry, and 50 neutral faces. As fillers, we selected 299 faces from the AR Face Database (Martinez & Banavente, 1998). All facial stimuli were presented in full color with a resolution of 531 * 720 pixels. For the aim of the present study we used letters as T2 stimuli because they are emotionally neutral and have been often used in AB research. Some similarity between the targets seems necessary to elicit an attentional blink (Raymond, Shapiro, & Arnell, 1995). We therefore selected letters containing circular, face-shape properties that we also used in a previous study (de Jong et al., 2009). The letters were painted in a way that optimized the similarity with the face probes in terms of color pattern, organicity, and size. To control for the influence of low-level stimulus features we selected 4 similar letters (p, d, q, b). The faces and the letters were presented against a white background (see Appendix 1 for a sample item).

Rapid Serial Visual Presentation Task

The present dual-target RSVP task was based on the task we used in our previous study (de Jong et al., 2009), with each trial consisting of a T1, fourteen non-targets, and a T2. There was no inter-stimulus interval within the stream. All T2s were letters, all T1s facial expressions, and all distracters were neutral facial expressions that were presented inversed (rotated 180°). Each trial consisted of a rapid serial temporal presentation of 16 stimuli (118 ms/item). T1 was randomly presented on one of three possible positions in the stream (position 6, 7, or 8). T2 was randomly presented at position 1, 3, 5, or 7 following T1 (i.e., lag 1, 3, 5, or 7).

Accordingly SOAs were 118, 354, 590, and 826 ms. Each combination of T1 position and T2 position was presented equally often. There were 3 (T1: angry, happy, neutral) x 4 (T2: p, q, b, d) x 4 (Lags: 1, 3, 5, or 7) = 48 different types of trials. The male and female faces were balanced across the target combinations. A total number of 192 trials were presented in 4 similar blocks of 48 trials (i.e., each combination of T1 and lag was repeated 16 times in total) with a 30 s break following each block to reduce the influence of fatigue and problems with participants' concentration. Each trial started with a fixation cross (500 ms).

Procedure

Participants were tested individually. At the end of each trial, participants were required to indicate whether or not they had seen an upright face, and if so, to indicate what expression was evident on the face as angry, happy, or neutral. Subsequently, participants were requested to indicate whether or not they had seen a letter, and if they did, to identify the letter as p, q, d, or b. After a practice stage the experimenter left the experiment room, and the actual experiment started.

Results

Influence emotional expression on correct identification of T1

A 3 Emotion-T1 (happy vs. angry vs. neutral) x 2 Group (high vs. low socially anxious) ANOVA on correct T1 identification rates showed a significant main effect of Emotion [$F(2,118) = 12.20$, $p<.05$, $\eta^2 = .171$]. None of the other effects reached significance. Pairwise comparisons with Bonferroni correction indicated that participants were generally less accurate to identify Neutral T1 faces (M = 81 % SE = 2.0) than Happy faces (M = 89 %, SE = 1.4) ($p < .001$), or Angry faces (M = 87 %, SE = 1.2) ($p < .005$), whereas the accuracy of identifying Happy and Angry faces did not differ significantly ($p = .12$).

Influence emotional expression on correct identification of T2

Because the appearance of particular emotional expressions may influence subsequent target identification even if participants are not accurate in their identification of T1, the primary analysis focused on T2 identification as a function of the facial expression presented as T1, irrespective of actual T1 performance. Yet, by and large the conditional performance showed a very similar pattern (see footnote 1). Mean percentage of correct identifications of T2 are displayed in Table 1.

A 3 Emotion-T1 (angry vs. happy vs. neutral) x 4 Lag (1 vs. 3 vs. 5 vs. 7) x 2 Group (high vs. low socially anxious) ANOVA revealed a main effect of Lag [$F(3, 177) = 78.6$, $p<.01$, $\eta^2 = 0.57$], indicating that participants showed an attentional blink when the time interval between T1 and T2 was short, whereas the blink diminished when the time interval was long (correct identification of the T2 letter stimuli was about 54 % for lag 1, 66 % for lag 3, about 78 % for lag 5, and 77 % for lag 7)[2]. There was a significant main effect of Emotion [$F(2,118) = 3.8$, $p<.05$, $\eta^2 = .061$]. Pairwise comparisons with Bonferroni correction indicated that participants were generally more accurate to identify T2 following Happy (M = 69.8, SE = 2.2) than following Neutral (M = 68.3, SE = 2.4) ($p < .05$) or Angry faces (M = 68.6, SE = 2.2) ($p < .05$), but did not differ significantly between Neutral and Angry face trials ($p > .15$). There were no differences between high and low socially anxious individuals in this respect ($F < 1$). Most important, the effect of Emotion-T1 on T2 identification accuracy varied as a function of Lag [$F(6,354) = 4.52$, $p <.05$, $\eta^2 = .071$]. This pattern was similar for both groups as was evidenced by the absence of a Lag x Emotion x Group interaction [$F(6,354) = 1.06$, $\eta^2 = .02$].

For a proper interpretation of the Emotion by Lag interaction, we tested the relevant Emotion contrasts for each of the Lags separately. For Lag 1 (SOA 118 ms), pairwise comparisons with Bonferroni correction indicated that participants were less accurate to identify T2 following angry (M = 52.5, SE = 2.9) than following neutral faces (M = 56.4, SE = 3.1) ($p < .05$), whereas the accuracy of identifying T2 following happy faces (M = 54.3, SE =

3.1) did not differ from angry or neutral trials (*p*s > .20) (see also Figure 1). For lag 3 (SOA 354 ms), pairwise comparisons indicated that participants were less accurate to identify T2 following angry (M = 63.4, SE = 3.0) than following happy (M = 69.3, SE = 2.8) ($p < .01$) or neutral faces (M = 67.3, SE = 2.8) ($p < .05$).There were no significant differences between neutral and happy face trials in this respect ($p > .20$) (see also Figure 1).

For lag 5 (SOA 590 ms), participants showed no longer a difference in T2 detection accuracy between angry and happy faces ($p > .80$). Yet, for this T1-T2 time interval they were less accurate to identify T2 following neutral (M = 74.1, SE = 2.3) than following angry (M = 79.8, SE = 2.3) ($p < .001$), or happy T1 faces (M = 80.0, SE = 2.2) ($p < .001$). For lag 7 (SOA 826 ms), there was no longer evidence for differential influence of neutral (M = 76.9, SE = 2.6) vs. angry (M = 77.9, SE = 2.5) vs. happy (M = 78.6, SE = 2.3) T1 faces on T2 identification accuracy (*ps* > .06).

Discussion

Supporting the notion that the identification of social threat cues is associated with temporal attention depletion, participants showed a stronger AB when the T1 target displayed an angry rather than a happy facial expression. Consistent with conceptually similar research in the context of depression (e.g., Koster et al., 2009), this effect was only found when T2 was presented in close temporal proximity to T1 (SOA = 354 ms). The effects were independent of social anxiety.

Emotion-Induced Attentional Blink

The present findings show that the identification of threat cues is associated with hampered identification of subsequent appearing task relevant information. This is in line with evolutionary models proposing that threatening information has privileged access to limited cognitive resources to increase the chances of survival in the context of threat (e.g., Öhman, Flykt, & Lundqvist, 2000). The present study complements previous work presenting emotional faces as T2 and neutral letter stimuli as T1 (de Jong et al., 2009). Supporting the notion that emotional expressions receive preferential processing, this previous study showed an attenuated AB for emotional faces. Interestingly, in this previous study both angry and happy T2 faces showed a similarly lowered threshold for accurate identification compared to neutral faces. Together the available evidence suggests that irrespective of social anxiety levels positive and negative face stimuli are processed relatively efficiently, whereas especially threatening faces elicit elaborate processing that is associated with temporal attention costs.

The relatively strong impairment of identifying T2 stimuli when shortly preceded by angry T1 faces is in line with the anger superiority hypothesis, which states that facial expressions that indicate social threat are preferentially processed. This finding in the present study may also explain the previously observed larger attentional blink when happy faces followed angry faces rather than vice versa (de Jong & Martens, 2007). In addition, this finding is consistent with results indicating that identification of T2 words are hampered when highly emotionally salient stimuli are used as T1 stimuli (Mathewson, Arnell, & Mansfield, 2008).

It should be acknowledged, however, that alternative explanations can be raised for the anger superiority effect here. First, it is possible that the smaller AB effect after happy rather than angry faces might reflect the broadening attentional influences of positive emotions (Fredrickson & Branigan, 2005). However, this seems unlikely because at the short lags happy faces did not facilitate T2 detection in comparison to neutral faces. Second, one could argue that angry faces are just more salient than happy or neutral faces and that this enhanced saliency might be the driving force behind the enhanced AB following angry face T1 stimuli. However, the finding that T1 accuracy was very similar for angry and happy faces renders this explanation not very convincing. In addition, earlier research using the same facial stimuli as T2 showed that the AB was similarly attenuated for happy and angry faces (de Jong et al., 2009), supporting the view that the saliency of both types of emotional faces is in fact very similar. Moreover, it has been shown that saliency per se is not sufficient to enhance the AB (e.g., using one's own name as T1 was found not to produce an enhanced AB compared with using names of other people (Shapiro et al., 1997)).

As a third possibility it could be that there is a larger similarity between the angry faces and the letter stimuli. However, if differential similarity would have caused the enhanced blink when angry faces preceded the letter stimuli, one would predict a similarly enhanced AB when letters would be presented as T1 followed by angry T2 faces. Yet, a previous study using exactly the same stimuli as were used in this study found no evidence for such an enhanced AB when angry faces were presented as T2 (de Jong et al., 2009). Moreover, to minimize the chance that accidental low level perceptual features would drive the results we used face stimuli of 50 different actors, with the same actors portraying the three target expressions. Thus all in all it seems most parsimonious to explain the present enhanced blink on angry face trials in terms of enhanced processing priority of threatening stimuli at the expense of attentional costs.

Perceptual distinctness does seem a likely candidate to explain the finding that especially at the longer lags identification accuracy following neutral faces was relatively low. Because of the absence of salient cues, proper identification of neutral expressions might well be associated with higher cognitive costs that interfere with T2 identification. Consistent with this, T1 identification of neutral faces was relatively poor.

Individual differences in social anxiety and enhanced AB

No evidence emerged to suggest that performance in high socially anxious individuals was especially hampered by preceding social threat cues. However, it is important to note that participants in this study were explicitly instructed to identify the emotional expressions that were presented in the RSVP streams. This instruction may well be congruent with social anxious individuals' habitual tendency to be highly vigilant for social threat cues (Rapee &

Heimberg, 1997). However, the present instruction may have induced a similar strategy in low socially anxious participants. Thus, under conditions of a top-down search for emotional faces there is no evidence for exaggerated allocation of attention to disapproving faces in high socially anxious individuals. It would be interesting in future research to present emotional faces as task-irrelevant distracters rather than as targets in a single target RSVP (e.g., Arnell, Killman, & Fijavz, 2007), as such procedure would allow to examine the attentional costs of more spontaneous (bottom up) processing of emotional expressions.

At first glance, the absence of a difference between high and low socially anxious individuals seems inconsistent with earlier findings suggesting that the magnitude of the AB is modulated by anxiety (e.g., Fox et al., 2005). Yet, in this previous study showing that especially in high trait or state anxious individuals the magnitude of the AB is reduced for fearful faces, these expressions were presented as T2 rather than as T1. As discussed above, different processes seem involved when facial expressions are presented as T2 instead of as T1, and these processes may also be differentially affected by anxiety. In addition, there may be important differences between trait anxiety and social anxiety in this respect. Germane to this, earlier research using face stimuli as T2 did not found any evidence for an attenuated AB on angry face trials in high socially anxious individuals (de Jong et al., 2009; de Jong & Martens, 2007). Moreover, fearful faces and angry faces may be processed differently. It would therefore be interesting in subsequent research to directly compare fearful and angry faces in one design.

Conclusion

This study is the first to show that angry faces are processed in a temporally distinct fashion, causing a momentary lowered attention for stimuli presented within close temporal proximity. This finding lends support to theories assigning a special status to the cognitive processing of threatening facial expressions in a way to enhance chances of survival in threatening contexts.

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Footnote

1. Results of T2 performance conditional on correct T1 identification showed a very similar pattern. Also here there was a significant Emotion-T1 by Lag interaction [$F(6,354) = 2.24$, $p < .05$, $\eta^2 = 0.04$], that was independent of social anxiety [$F(6,354) = 1.04$, $\eta^2 = 0.02$]. Similar to the pattern of unconditional performance, specifically for lag 3 participants were less accurate to identify T2 following angry (M = 65.5, SE = 3.0) than following happy faces (M = 69.7, SE = 2.9) ($p < .05$), although in this case the accuracy of identifying T2 following neutral faces (M = 67.3, SE = 2.9) did not differ significantly from angry or happy trials (*ps* > .20). Furthermore, also conditional performance for lag 5 showed that participants were typically more accurate to identify T2 following angry (M = 82.2, SE = 2.1), or happy T1 faces (M = 81.5, SE = 2.2) than following neutral (M = 76.9, SE = 2.3) (*ps* < .05), whereas for Lag 7 there was no longer evidence for differential responding. Further details can be obtained from the first author upon request.

2. There was no lag-1 sparing, which is a common finding when T1 and T2 represent different categories of stimuli (in this study faces vs. letters) (for a relevant review see Visser, Bischof, & Di Lollo, 1999).

Table 1. Mean (SE) Percentage Correct T2 Identification as a Function of Emotional Expression of T1, Lag, and Social Anxiety.

	High Anxious			Low Anxious		
	Angry	Happy	Neutral	Angry	Happy	Neutral
Lag 1	54.2 (4.0)	57.9 (4.3)	59.3 (4.3)	50.6 (4.1)	50.0 (4.4)	53.3 (4.4)
Lag 3	67.3 (4.1)	72.8 (3.9)	71.6 (3.8)	59.4 (4.2)	65.6 (3.9)	62.9 (3.9)
Lag 5	82.5 (3.2)	82.1 (3.2)	74.4 (3.2)	77.1 (3.2)	77.9 (3.2)	73.8 (3.3)
Lag 7	78.8 (3.6)	79.4 (3.3)	80.2 (3.6)	76.9 (3.6)	77.7 (3.3)	73.5 (3.7)

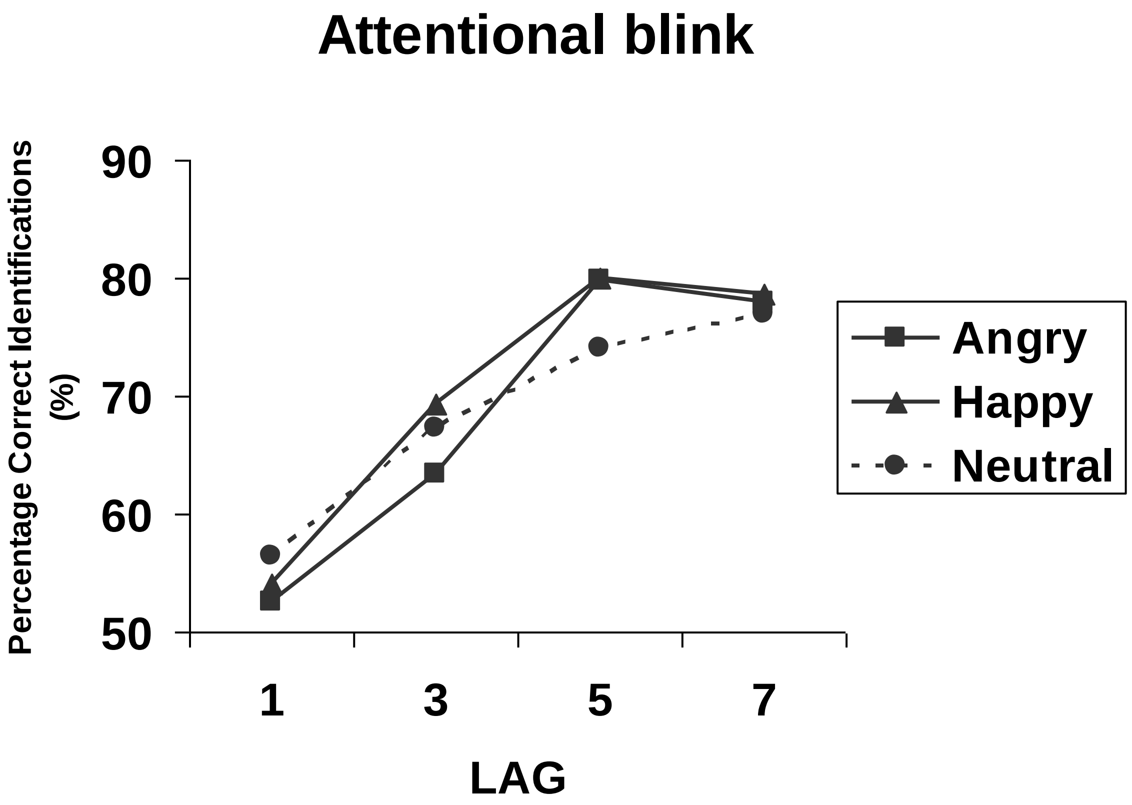

Figure 1

Mean percentage correct T2 identifications, independent of T1 accuracy (unconditional performance), as a function of emotional expression (happy, angry, neutral) and time interval between T1 and T2 (lag 1 to lag 7).

Appendix 1: Illustration of the Critical Part of a Typical Trial. The Target (Face) and the Probe (Letter) are Presented in a Stream of Rotated Faces.